Standoff Time-Resolved Raman and Fluorescence Spectrometer for a Lunar Lander.

M. Sandford[1], A. K. Misra[1], T. E. Acosta-Maeda[1], J. Porter[1], M. Egan[1], S. K. Sharma[1], S. M. Clegg[2], R. C. Wiens[2], and M. N. Abedin[3], [1]Hawaii Institute of Geophysics and Planetology, Univ. of Hawaii at Mānoa, Honolulu, HI 96822, USA; [2]Los Alamos National Laboratory, Los Alamos, NM 87545, USA; [3]NASA Langley Research Center, Hampton, VA 23681, USA. msandfor@hawaii.edu

Introduction: A wide array of lunar science problems can be addressed by an understanding of the mineralogy of the surface. Raman spectroscopy is a powerful and widely used technique for characterizing the structure and chemistry of molecular compounds, and is well suited to the full array of lunar science problems [e.g. 1-4].

We have developed a standoff laser Raman system that is capable of obtaining high quality spectra at ranges over 100-m. The system also collects time resolved fluorescence data for sensitive detection of organics and fluorescent lunar minerals. Raman spectroscopy can detect and characterize the chemistry of all the major and minor lunar minerals. This characterization includes the major element ratios of the major minerals (for example, the forsterite content of olivine), and the chemistry of rarer minerals such as spinel. Raman spectroscopy can also be used to characterize glasses that might be featured at a landing site at a pyroclastic deposit.

Methods: Our compact portable remote Raman system consists of a frequency-doubled mini Nd:YAG pulsed (532 nm, 10 ns pulse width, 20 mJ/pulse, 20Hz) laser source, a 3 inch diameter telescope, a compact spectrograph with dimensions 10 cm (length) x 8.2 cm (width) x 5.2 cm (height) and a mini-ICCD detector. The system details have been previously discussed in Misra et al. (2015) [5]. The spectra in this experiment were collected in daylight conditions from 122 m using the intensified CCD in gated mode with 70 ns gate width. A short gate width helps in minimizing the background signal from daylight and mineral phosphorescence.

Results and conclusions: Figure 2 shows the Raman spectra for liquid water (H_2O), ice water, and CO_2 ice measured at 122 meters distance in daylight conditions [6]. The liquid water spectrum shows the strong, broad Raman bands at 3278 and 3450 cm^{-1} are the symmetric (ν_1) and antisymmetric stretching (ν_3). The Raman spectrum of CO_2- ice has a characteristic Fermi resonance doublet at 1284 cm^{-1} and 1392 cm^{-1}. Remote Raman spectra also show the presence of atmospheric gases, O_2 at 1556 cm-^{1} and N_2 at 2331 cm^{-1} [2, 3].

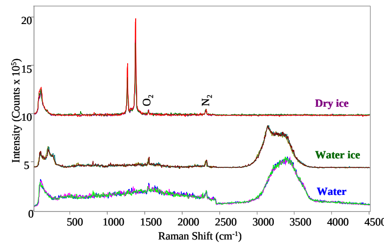

Figure 2: Remote Raman detection of liquid water, water-ice and CO_2 ice from 122 m with 30s integration time.

References: [1] S. K. Sharma et al (2006) *Appl. Spectrosc.* **60**, 871-876. [2] A. K. Misra et al. (2007) *Proc. SPIE*, **6681**, 66810C/1-14. [3] T. Acosta-Maeda, et al. (2016) *Applied Optics*, 55, 10283-10289. [4] M. N. Abedin, et al. (2018) *Applied Optics* 57, 62-68. [5] A. K. Misra et al. (2015) *46th LPSC*, Abstract #1553. [6] M. Sandford et al., (2018) *49th LPSC*, Abstract #1695.